

Mathemat & vol 3.

REMARKS

ON A

PAMPHLET

Lately published by the

Rev. Mr. *MASKELYNE*,

Under the AUTHORITY of the

BOARD OF LONGITUDE.

By *JOHN HARRISON.* *K*

THE SECOND EDITION.

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REVIEW

ON A

PAMPHLET

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REMARKS,

ON A

PAMPHLET, &c.

A PUBLICATION having lately been made by the Rev. Mr. *Maskelyne* Astronomer Royal, under the Authority of the Board of Longitude, manifestly tending, by the Suppression of some Facts and the Misrepresentation of others, to impress the World with an unjust Opinion of my Invention, and falsely asserting that my Watch did not at certain Periods therein mentioned keep Time with sufficient Exactness to determine the Longitude within the Limits prescribed by the Act of the 12th of Queen *Anne*; I think it incumbent upon me to submit some Observations thereon to the impartial Publick; and the rather, because the said Pamphlet is rendered so confused by unnecessary Repetitions, and voluminous Tables, that a Man must be pretty conversant in these Matters, to trace and combine
A the

the Facts, so as to check the Conclusions, which would consequently be taken upon Trust by the generality of Readers, unless publickly contradicted. As it will be my Endeavour so far to avoid the Use of all Terms of Art as to make the Subject generally intelligible, I flatter myself I shall not be thought impertinent for giving a short Explanation (though quite unnecessary to the far greater Part of my Readers) of what the Longitude is, and what the Service required of the Watch.

The Longitude of any Place is its Distance East or West from any other given Place; and what we want is a Method of finding out at Sea, how far we are got to the Eastward or Westward of the place we sailed from. The Application of a Time-Keeper to this Discovery is founded upon the following Principles: The Earth's Surface is divided into 360 equal Parts (by imaginary Lines drawn from North to South) which are called Degrees of Longitude; and it's daily Revolution Eastward round it's own Axis is performed in 24 Hours; consequently in that Period, each of those imaginary Lines or Degrees, becomes successively opposite to the Sun (which makes the Noon or precise Middle of the Day at each of those Degrees); and it must follow, that from the Time any one of those Lines passes the Sun, till the next passes, must be just four Minutes, for 24 Hours being divided by 360 will give that Quantity; so that for every Degree of Longitude we sail Westward, it will be Noon with

with us four Minutes the later, and for every Degree Eastward four Minutes the sooner, and so in Proportion for any greater or less Quantity. Now, the exact Time of the Day at the Place where we are, can be ascertained by well known and easy Observations of the Sun if visible for a few Minutes at any Time from his being ten Degrees high 'till within an Hour of Noon, or from an Hour after Noon 'till he is only 10 Degrees high in the Afternoon; if therefore, at any Time when such Observation is made, a Time-Keeper tells us at the same Moment what o'Clock it is at the Place we sailed from, our Longitude is clearly discovered. To do this, it is not necessary that a Watch should perform it's Revolutions precisely in that Space of time which the Earth takes to perform her's; it is only required that it should invariably perform it in *some known Time*, and then the constant Difference between the Length of the one Revolution and the other, will appear as so much daily gained or lost by the Watch, which constant Gain or Loss, is called *the Rate of its going*, and which being added to or deducted from the Time shewn by the Watch, will give the true Time, and consequently the Difference of Longitude.

I shall now proceed to make such Remarks as occur to me on Perusal of Mr. *Maskelyne's* Pamphlet.

Mr. *Maskelyne* begins by telling us that the Board of Longitude, at their Meeting, *April*

26, 1766, came to a Resolution that my Watch should be tried at the Royal Observatory under his Inspection, and that he accordingly received it on the 5th of *May*, 1766. He then says, "I most Days wound up and compared the Watch with the transit Clock of the Royal Observatory myself; at other times it was performed by my Assistant *Joseph Dymond*, and afterwards *William Bailly*; this was always done in the Presence of, and attested by one of the Officers of *Greenwich Hospital*, when he came to assist in unlocking the Box in which the Watch is kept, in order to its being wound up."

Not one of those Attestations appears in the Book: Perhaps Mr. *Maskelyne* thinks his Assertion of the Fact will be sufficient for the Publick, and indeed so it might have been to me, had I not received different Information: But the Truth is, the Commissioners appointed a Set of Gentlemen to attend by Rotation the winding up of the Watch; they were to unlock the Box the Watch was in, to see it wound up and compared with the Clock, then to lock the Box again and take the Key with them, and Mr. *Maskelyne* was to have another Key, there being two Locks to the Box:• The Officers

* It may not perhaps be improper here to observe, that the Locks were such as might be picked with a crooked Nail, that the Lock of which the Officers had the Key was on the 10th of *July* out of Order, and that Mr. *Maskelyne* was sorry this should ever come to the Ear of the Publick.

cers of *Greenwich* Hospital were appointed for this Service, some of whom from the Infirmities of Age, and Misfortunes in the Service, were scarce able to get up the Hill to the Observatory, so that when they came there, as can be proved from undoubted Eye Witnesses, they only unlocked the Box, sat down 'till Mr. *Maskelyne* had done what he thought proper, and then locked the Box again, and departed: and whatever Attestation they may be supposed to have made, I can prove that at several Times when Gentlemen of my Acquaintance happened to be present, the Attendance of the Officers was by no Means an effectual Check upon the Comparison of the Watch with the Clock. I would not be thought to accuse those Gentlemen of Neglect of the Duty imposed upon them; on the contrary I applaud their Diligence in being ready at all Hours of the Day to attend when Mr. *Maskelyne* was pleased to appoint; and therefore I will even for the present (though contrary to Fact) suppose they have been the Check proposed by the Commissioners of Longitude against any unfair Access to the Watch, still the Clock with which it was compared was left entirely in Mr. *Maskelyne's* Power, and an Alteration of the one could not but produce just the same Effect as an Error of the other, nor is there even the least Pretence of a Check either on the Clock, or on its Comparison with Observations of the Sun; nay on the contrary, Mr. *Maskelyne* did at this Time take the Key of the Clock from Mr. *Dymond* in whose Custody it used to be, and kept it himself.

Mr.

Mr. *Maskelyne* then proceeds to give us an Account of the Watch's going from Day to Day, which in his 15th Page he concludes thus: " From the foregoing Numbers it appears, that the Watch was getting from the very first near 20 seconds per day; a circumstance which is not my business to account for; but which, as it kept near mean Time in the Voyage to Barbadoes, seems to shew that the Watch cannot be taken to pieces and put together again without altering its Rate of going considerably, contrary to Mr. *Harrison's* Assertions formerly."

When I made the Discovery, upon Oath, of the Principles and Construction of the Watch, to six Gentlemen appointed by the Board of Longitude and to Mr. *Maskelyne*, (who insisted on having a Right to attend, as being a Commissioner) which Discovery was finished on the 22d Day of *August*, 1765, as appears by the annex'd Certificate,* the

Watch
* " We whose Names are hereunto subscribed do certify, that Mr. *John Harrison* has taken his Time-Keeper to Pieces in the Presence of us, and explained the Principles and Construction thereof, and every Thing relative thereto, to our entire Satisfaction; and that he also did to our Satisfaction answer to every Question proposed by us or any of us relative thereto; And that we have compared the Drawings of the same with the Parts, and do find that they perfectly correspond."

August 22, 1765.

Newt Maskelyne,
John Michell,
William Ludlam,
John Bird,
Thomas Mudge,
William Matthews,
Larcum Kendall.

Watch then remained in my Hands, all taken to pieces: I little imagined the Board of Longitude would take it from me, as not conceiving any Use they could make of it; and having besides received Assurances from them, that they only wanted the formal Delivery of it, in compliance with the Terms of the new Law, without meaning to deprive me of the Use of it: I therefore went on making some experiments, and alter'd the Rate of its going, thereby to determine a Fact I wanted to be satisfied about. The Watch was under this Experiment the latter End of *October*, 1765, when upon receiving the Certificate for the Remainder of the first Moiety of my Reward, I was ordered to deliver it to the Board. My Son, attending with it, being asked if it was then as fit as before to ascertain the Longitude, reply'd in the Affirmative; for as I have before shewn, the *Rate of its going*, when once ascertained, does not prevent its keeping the Longitude. He was not asked the present Rate of its going, nor could he have answer'd with precision if he had, because we had not had Notice sufficient to determine that Point; but we did, at that Time, tell several of our Friends that it went about 18 or 19 Seconds a Day, *fast*, and we have at several Times since (without ever dreaming that this was to become a Point of public Discussion) had Occasion to mention the same Thing to several Members of Parliament, Commissioners of Longitude and other Gentlemen, inso-much that we did not believe any body was unin-

uninformed of it, who at all attended to the Business of the Longitude.

This may serve to account for the Circumstance which Mr. Maskelyne declares, *it was none of his Business to account for*, why the Watch was getting near 20 Seconds per Day; but as to *his Inference*, I must say it betrays the most absolute Ignorance of Mechanics, and of this Machine in particular, in which it is obvious (and for this Fact I appeal to the Watchmakers who saw it taken to Pieces) that its going at the same Rate when put together again, as before, depends (if none of the Parts are alter'd) upon nothing more complicated *than putting a single Screw into the same Place from whence it was taken*. Indeed this Passage, and the ignorant and puerile Remarks which Mr. Maskelyne has been suffer'd to prefix to my written Description of the Watch (to the Disgrace of this Country in those foreign Translations it has already undergone) bring strongly to my Remembrance an Observation made by some of the Gentlemen present at the Discovery, " that they wonder'd at his Patience
" in attending so long to a Subject he seem'd
" so totally unacquainted with."

Mr. Maskelyne then proceeds to tell us of a Change that happen'd in the going of the Watch, and says, " this Change began in
" the Beginning of *August*, on the few and
" only hot Days we had last Summer,
" which yet were not extreme, the Ther-
" mometer within Doors having never risen
" above

“ above 73° . the Rest of the Summer in
 “ general was remarkably cool and tempe-
 “ rate.” When I took this Watch to Pieces
 I informed Mr. *Maskelyne* and the other
 Gentlemen, that in trying any Experiments
 with it, in Respect to Heat and Cold, it
 would be proper that it should be so fixed
 that, as far as could be, the Heat should
 have an equal Influence on all Sides of it;
 and it is obvious that the Thermometer
 ought to have been kept in the same Box
 with it; but as this was not done, I appre-
 hend the Effects of Heat mention’d above
 do not merit much Attention; and therefore
 shall only observe that the Watch was placed
 in a Box with a Glass in the Lid and ano-
 ther in one Side, in the Seat of a Window
 level with the lowest Pane of the Window,
 and exposed to the South East, whilst the
 Thermometer, which was to ascertain the
 Degree of Heat the Watch was exposed to,
 was placed in a shady Part of the Room:
 Now ’tis obvious that while the Air sur-
 rounding the Thermometer might be very
 temperate, there might, if the Sun shone
 upon it, be a heat in the Box, superior
 to what was ever felt in the open Air in
 any Part of the World; and perhaps greater
 than any human being could subsist in, and
 consequently improper, or at least unne-
 cessary for this experiment.

Mr. *Maskelyne* next tells us of an irregu-
 larity which he says happened in cold Wea-
 ther, and says, “ However, it seems in ge-
 “ neral that the Frost must have been the
 B “ cause

“ cause of these irregularities, as well as
 “ of the Watch’s going so much slower in
 “ the Month of *January*, than it had gone
 “ before.” Mr. *Maskelyne* ought along
 with this, to have published what I told
 him when I explained it; that the Provision
 against the effects of Heat and Cold was
 not *in this Machine* extended to all De-
 grees; that I never had tried it so low as
 the freezing Point, which according to the
 best Informations I have been able to pro-
 cure is a Degree of Cold *that never did exist*
between the Decks of a Ship at Sea, in any Cli-
 mate yet explored by Mankind.

Mr. *Maskelyne* then comes to the Rate
 of its going in different Positions; and says,
 “ It is obvious, these last-mentioned Trials
 “ of the Watch in a vertical Position could
 “ not be designed to shew how near it would
 “ go at Sea, where it can never obtain these
 “ Positions: the Intent of them is to prove
 “ how near Mr. *Harrison’s* Execution of
 “ his Watch comes up to his Principles,
 “ with respect to the making all the Arcs
 “ described by the balance, whether large
 “ or small, to be performed in the same
 “ Time, as Mr. *Harrison* asserts them to
 “ be.” Mr. *Maskelyne* here also might have
 had Candour enough to inform the Public,
 as I did him, that although the Watch was
 quite sufficient to answer the Purposes re-
 quired of it in Navigation, and to fulfil
 what was prescribed by the Act of Queen
Anne, yet it was far from being in a state of
 Perfection, *as an universal exact Time-Keeper*
 for

for every Purpose: I shew'd him and the rest of the Gentlemen the Reasons why the Machine then before them, would not go at the same Rate in such different Positions *into which the Motion of a Ship could never put it*; and whilst I explained to them those Imperfections in the particular Machine we were examining, I also in the clearest Manner I was able, pointed out the means of remedying them with certainty in others, which the Gentlemen skill'd in Mechanics seem'd perfectly to comprehend, and to be satisfied of the Truth which I again assert, that Watches made on my Principles will endure a much greater Motion and change of Position than they can ever be subject to in a Ship; and that they will not be affected by any Degree of Heat or Cold, in which a Man can live.

If any Thing was meant to be concluded with respect to me by this Experiment, either in Point of Property or of Reputation, common Justice would have required that I should have had an Opportunity of seeing the Facts ascertained; and when such a Trial was directed as put the Result in the absolute Power of a single Person, that I should have been satisfied of his Integrity Disinterestedness and Ability for the purpose. I would not be understood to attack Mr. *Maskelyne's* Knowledge of the Theory of Astronomy; as for any Thing I know to the contrary, it may be of the very first Rate, especially as the Commissioners have thought proper to entrust him with the Execution of
their

their commands; and which he has ever been as ready to undertake: But alas! as to his skill in Mechanics, he knows little or nothing of the matter he has ventur'd to take in Hand.

I think it more consistent with the respect I owe to the Public, and myself, to speak out plainly, than to have recourse to *Insinuations*, on a Subject of this nature: I therefore declare, that I am not satisfied with the Truth of his reporting other Observations relative to the Longitude, as I do maintain that in both his Voyages the Observations which he said he made the Land by, were not calculated till after he had seen the Land; and I am certain those he has given, in the Publication now before us, are not genuine, for he pretends to find each Observation of the Transit of the Sun to the hundredth part of a Second of Time,—a Degree of exactness about twenty Times beyond what any other Observer has hitherto found practicable: Moreover I know him to be deeply interested in the Lunar Tables, a Scheme set up some Years ago for the Reward in Competition with my Invention, and for which large Sums of Money have already been paid by the Public.

Although I flatter myself the Reader is already in Possession of very sufficient Reasons for rejecting the whole Pamphlet as partial and inconclusive, yet I entreat his patient Attention whilst I advance one step farther

farther, and shew, that although Mr. *Maskelyne* has presented us with a set of Observations which *according to his mode of Calculation*, prove what he advances, yet those very Observations when rightly reasoned upon *prove the contrary*; and that in each of the Periods he refers to, except those of the severe Frost and improper Positions (against which Mr. *Maskelyne* ought to have informed the World I never warranted this particular Watch) it kept Time with sufficient correctness to determine the Longitude within the limits of the Act of Queen *Anne*.

The Reader by this Time knows enough of the Subject to see, that in order to try whether the Watch would or would not keep Time with sufficient Exactness to determine the Longitude, Mr. *Maskelyne's* first Operation, after receiving it, should have been to ascertain *the Rate of its going*. But no such Thing happened: he knew it had not gone exactly correspondent to mean Time, during the Voyage to *Barbadoes*; it had been publicly enough declared that its Rate of going had been since altered; and, if he had not received that Information, he might nay must have discovered it in the first 24 Hours Tryal; however, without once attending to this *essential Circumstance*, he goes to work, comparing the first Period of six Weeks (which he observes is generally reckoned the Term of a West-India Voyage) when it was in an horizontal Position, with *mean Time*, instead of *the corrected Time*, and each succeeding Period with that immediately preceding

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ing it! Who can hesitate in pronouncing that his Conclusions must be all erroneous? He should first have ascertained the Rate of its going by a Length of Observations of the Sun or Stars, or by a perfect Pendulum Clock if he had such a one, and then have corrected the Time shewn by the Watch accordingly. However, supposing for a Moment his *Facts* to be genuine, I will deduce the *real Result* in the best Manner the Observations will admit, rejecting those made while the Watch was in improper Positions, and those during the Frost, for the same Reasons that Mr. *Maskelyne* lays no Stress upon them, and for those I have already stated. I shall therefore (pursuing his Idea of six Weeks) take it during the first tranquil six Weeks that it had, viz. from *July* the 6th, to *August* the 17th, in which Time it gained in all 11 Minutes, 50 Seconds, or $16 \frac{2}{10}$ Seconds per Day which I will assume as the Rate of its going, or if Mr. *Maskelyne* pleases I will take the Average of his whole Time of Examination, from the 6th of *July* to the 3d of *January* and from the 9th of *January* to the 4th of *March*, which will come out at the Rate of $16 \frac{8}{10}$ Seconds per Day fast, and I say that according to either of those Rates of going, the Watch kept the Longitude within the Limits of the Act of Queen *Anne*, during any Period of six Weeks that can be pointed out, excepting those of extreme Cold, and improper Position which have already been explained. I do not trouble the Reader with the Calculations: If I assert an Untruth,

Untruth, I shall hardly escape Contradiction.

There is another Inaccuracy, which tho' of less Consequence, ought not to escape notice. One would naturally suppose when Mr. *Maskelyne* found the Watch went at this Rate of gaining on Mean Time, he would have been very exact in his Time of comparing it with his Clock ; but on the contrary we find he was so irregular as to vary his Comparisons on succeeding Days from half an Hour to four Hours and 48 Minutes, and this not for a Time or two, but for one third of the whole Time he had it.

Mr. *Maskelyne* having shewn from the Result of his Calculation (which I have here proved to be false) that the Watch is not to be depended upon to determine the Longitude in a Voyage of six Weeks, then says, " these Considerations are sufficient to explain the Motives which might have actuated Mr. *Harrison*, as a Man of Prudence, in desiring to send his Watch two Voyages to the West Indies, upon his Idea that he should be intitled to the large Rewards prescribed in the Act of the 12th of Queen *Anne*, in Case his Watch kept Time within the Limits there mentioned, whether the Method itself was or could be rendered generally useful and practicable, or not ;" this Insinuation (*published under the Authority of the Commissioners of Longitude*) that I had contrived a Trial which I knew the Watch would fulfil, whilst I was conscious

ous that it would not answer the general Purposes of the Act of Queen *Anne*, and consequently that I had formed a villainous Scheme to rob the Publick of the Reward without really and effectually performing the Conditions, strikes me as a Charge of so atrocious a Nature, that I think myself not only *justified* in publishing to the World what has been done with respect to Trials of the Merit of my Invention, but even *indispensably obliged* so to do. I well know what I hazard thereby, and if the rest of my Reward cannot be obtained on Principles of *National Faith* and *Publick Spirit*, I am contented to forego it, but I will not descend into the Grave loaded with that Dishonour which my Enemies, availing themselves of their Rank or Offices, have, in various Ways, attempted to throw upon me.

In the first Place I must remark, that the Trial referred to was not fixed *by me*, but by *an Act of Parliament* passed so long ago as the Year 1714, which (after vesting certain discretionary Powers in Commissioners to judge what Methods are likely to prove practicable, and authorizing them to issue smaller Sums of Money) goes on to fix the last grand Test of the Merit of any such Invention, and enacts “ that when a Ship, under the Appointment of the said Commissioners, shall thereby actually sail from *Great Britain* to the *West Indies* without losing her Longitude beyond certain Limits, the Inventor shall be intitled to certain Rewards.” Having from the Year 1726, employed myself
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in adapting those Principles which I had at *that Time* executed in a Pendulum Clock, to an Instrument or Time-Keeper so constructed as to endure the Motion of a Ship at Sea, and having made a Voyage to *Lisbon* and done fundry other Things during a Course of Years, mostly under the Direction of the Commissioners of Longitude, by way of preparatory Experiments, I thought the Invention sufficiently perfect about the latter End of the Year 1760, to go upon the ultimate Trial, which I accordingly applied for. My Son, after being sent to *Portsmouth* with the third Time-keeper (the fourth or Watch being to be sent to him) was kept there five Months, waiting for Orders; which having by returning to *London* at Length obtained, he went to *Jamaica* in the *Deptford* Man of War, and returned in the *Merlin* Sloop of War, having fulfilled every Instruction of the Commissioners. It remained to compute from the Astronomical Observations made at *Portsmouth* and *Jamaica*, whether the Watch had or had not kept the Longitude within the prescribed Limits; and as my Title to 20,000*l.* was to be determined thereby, I thought it but reasonable that I should name some Person to check the Computations, *which was refused.* The Commissioners appointed three Gentlemen for that Purpose, and on receiving their Report were pleased to declare *that the Watch had not kept its Longitude within the above men-*

*tioned Limits.** Thoroughly convinced of the contrary (for I had the same Materials they had to calculate from) I required a Copy of the Computations *which was also refused me*; nor could I ever obtain a Sight of them either officially or through private Favour, 'till three Years afterwards, when they were ordered to be laid before the House of Commons; and it then appeared that two of the three Computations were absolutely inconclusive, proving nothing, and the third decided in my Favour. Further Proof of the Watch having succeeded in this Voyage may be found in the Journals of the House of Commons, Vol. XXIX. P. 546, in the Evidence of *George Lewis Scott Esq;* and *Mr. James Short.*

The Reader will easily believe I did not feel perfectly easy under this Treatment of an Invention to the perfecting of which (encouraged by the long continued Patronage of a *Graham*, a *Halley*, a *Folkes*, &c. &c.—learned Friends to Society, and Publick Good, whose Minds were too enlarged, and Spirits too liberal to admit that *little* Jealousy of inferior Artists, which since their

Death

* It may not be amiss to take Notice here of an Objection that was raised by two of the Commissioners, both famous for their Knowledge in Astronomy; viz. That the Observations of equal Altitudes made at *Portsmouth*, could not be depended on, because the equal Altitude Instrument had been removed from the Place of Observation in the Morning, to another Place to make the Afternoon Observations; from which it is plain that these great Astronomers did not understand either the Principles or Use of one of the most simple Instruments in Astronomy.

Death I have been exposed to) I gloried in sacrificing every Prospect of Advantage from other Pursuits, and had willingly submitted to lead a Life of Labour and Dependence. However 'twas too late to retreat; and I had only one Means of Success left which was to follow the Commissioners in their own Way. Accordingly after many Difficulties (with a Relation of which I will not tire the Reader, as it is by no Means my Intention to meddle with any Subjects of Complaint, except such as are material to the forming a right Judgment of the Trials made and proposed) a second Voyage to the *West Indies* was agreed to in the latter End of the Year 1762, which Agreement was afterwards well nigh overset by the Commissioners insisting on such Astronomical Observations being previously made, as were next to impracticable in this Climate, and could be put into the Instructions for no other Reason that I could conceive, but to throw insuperable Difficulties in my Way, as they were not at all material to the Determination of the Matter in Question. However the Commissioners at Length gave up this Point on my Opinion of the Impracticability being confirmed by that of an Officer of the Navy distinguished for his Abilities and Skill in Matters of Astronomy. To take away all Possibility (as I thought) of this Voyage being rendered fruitless like the last, I then desired to have inserted at the End of the Instructions some few Words to this Purpose, "that provided the Experiment answered, the Commissioners present were of

“ Opinion I should *without further Trou-*
ble receive my Reward;” but my Son
 attending the Board with this Proposi-
 tion was told by Lord *Sandwich* at that Time
 President, that it would be mere Tautology,
 for that their giving Instructions implied
 the same Thing, and that if the Watch kept
 its Time within the Limits of the Act there
 could be no Doubt of my being entitled to
 and receiving the Reward, and nobody
 could take it from me. Upon the Faith of
 this, my Son went the Voyage to *Barbadoes*,
 in which the Watch kept its Time “ con-
 siderably within the nearest Limits of the
 “ Act of Queen *Anne*,” as certified, even by
 the Commissioners themselves.

On the Success of this Trial being known,
 and after having employed near forty
 Years of my Life on the Faith of
 an Act of Parliament, was a Doctrine
 broached to me (as I solemnly declare *for*
the first Time) that the Commissioners were
 invested with a discretionary Power of or-
 dering other Trials and the fulfilling of
 other Conditions than those specially annex-
 ed by Act of Parliament to the Reward; *
 An Exposition of the Law, which I ever
 did and ever shall (until it is supported by
 legal Authority) totally reject and refuse
 Obedience to; for I do maintain, that be-
 fore passing the last Act of Parliament I had
 as full and perfect a *Right* to the Reward of
 20,000*l.* as any Free-holder in *Britain* has to
 his

* If this Interpretation of the Act was true, and the
 Commissioners had a general discretionary Power, where
 was the Reason or Use of specifying *any Trial at all* in
 the original Act?

his Estate ; and I never would have desired nor ever will desire any better Satisfaction than a judicial Determination of that Point ; which however it was very soon thought proper to preclude me from, by a new Law, passed at the Instance of the Commissioners of Longitude, placing me *too certainly* under the Discretion of the Commissioners and totally changing the Terms on which the Reward was to be given me, enacting that I should have half of it when I had disclosed the Principles, and Construction of the Machine, and assigned over for the Use of the Publick the last made Timekeeper, together with the three others which were not so perfect as the last ; and the other half when I should have made more Watches, *without determining how many*, and proved them to the Satisfaction of the Commissioners, *without defining the Mode of Trial*.

I frankly confess that from thenceforward I considered the second Moiety of the Reward as lost for ever. The first Moiety I obtained, tho' it was with great Difficulty, as the Act required me to explain my Invention upon Oath, and the Commissioners were pleased to put into that Oath, Words of an indeterminate and unlimited Meaning, and refused to explain them, or even permit me or my Son to ask what was meant by them. We at length agreed to take it (finding we should never get any Thing if we did not, such was now the Power of the Commissioners) and they declared that themselves and the Gentlemen appointed by them to whom
we

we were to explain it, would be *upon Honour* not to disclose it, that I might have an Opportunity of obtaining the Reward promised by foreign Powers; however, in less than a Month an Account of it appeared in the public News-Papers, signed by the Rev. Mr. *Ludlam*, one of the six Gentlemen named by the Commissioners to receive the Discovery, and therefore, I make no doubt, by Leave of the Board. Nor did they stop here, for they have since published all my Drawings without giving me the last Moiety of the Reward, or even paying me and my Son for our Time at the Rate of common Mechanicks; a Discouragement to the Improvement of Arts and Sciences, and an Instance of such Cruelty and Injustice as I believe never existed in a learned and civilized Nation before.

I have already had Occasion to mention, that at the Time I receiv'd the Certificate for the first Moiety of the Reward, the Watch was delivered up; it remained six Months locked up at the Admiralty, and was then removed to Greenwich, to be the Subject of those Experiments concerning which I now trouble the Public. The other three Machines, were (by Order of the Commissioners) soon after demanded of me by Mr. *Maskelyne*. One of them which had been going more than thirty Years, was broke to Pieces *under his careful and ingenious management*, before it got out of my House; and the other two were so far abused in the Carriage by Land to *Greenwich*, as to be rendered

dered quite incorrect, and as far as I can learn, incapable of being repaired without having some essential Parts made anew. Thus perished the first Essays of this long-wished for Invention!

Unwilling however that the Public should lose the Benefit of the Discovery, or the Chance of further Improvement, I applied, by repeated Letters, to the Board, praying that the Watch might be lent to me (offering Security for it if required) for the Sake of employing other Workmen to make the different Parts by Model, with quicker Dispatch, and in Order to determine by Experiments, whether some expensive Parts of the Machinery might not be abridged or totally left out. Still have my Requests been refused, and of late they have alledged that they cannot keep their Engagements with Mr. *Kendall* if they were to lend me the Watch. What those Engagements are may be seen below.* The new Act, as I have

* The Board contracted with Mr. *Kendall* (one of the six Persons to whom the Discovery was made) to make a Watch after the Model of mine. He was to be paid for every Thing before-hand, and to begin in a Twelvemonth after making the Bargain; he is to make Parts like Parts, but is not to be answerable for his Watch's going at all. My Timekeeper is now in his Possession, tho' he is not yet ready to make Use of it; There are some Parts in the making of which the Model can be of little or no Use to him; I only desired it for six or eight Months, and am confident he can have no Occasion for it before that Time is expired: however I have offered to have it forth coming whenever Mr. *Kendall* declares that he wants it, therefore I apprehend their Engagements with Mr. *Kendall* afford no solid Reason for the Commissioners to refuse lending it to me.

have already observ'd, did not determinē *how many* more Watches were to be made before I should receive the other Moiety of the Reward : it was seven Months before I could get them to fix *how many*, and then they would neither agree to any Mode of Trial propos'd by me, nor propose any themselves till *eleven Months* after that, viz. not till the 11th Day of *April* last, when (an Enquiry having been set on Foot in the House of Commons) they were pleas'd to propose, that instead of the Length of a *West-India* Voyage, which is about *six Weeks*, the Watches should be plac'd with their very good Friend and Well-wisher Mr. *Maskekyne* for *ten months*, and then be sent for two months on board a Ship in the *Downs*; and all this I am required to submit to, without the least Shadow of Assurance on their Part, that they will be satisfi'd with this Trial, let it answer ever so well, or that I shall thereby be brought at all the nearer receiving what is due to me, altho' (independent of making the Watches) it must necessarily employ one whole Year of mine or my Son's Time, in superintending an Examination, which, after all, can only prove that I, who have made one Machine, can make another like it; and the Point of general Practicability, about which so much stir is *affected* to be made, would not be one Jot advanced beyond what it is at present.

I cannot help begging the Reader will here allow me to add a Remark or two upon the general Practicability of my Invention,

as that is now said to be the only Thing that was in Dispute between the Commissioners and me, and that they only wanted to be satisfied as to this Point. In order to clear it up then, I will submit to the Public to determine whether the general Use and Practicability of my Invention can, in the Nature of Things, be attacked, unless under one of these three following Heads :

1. That a Time-keeper; however perfect, is an insufficient Means of ascertaining the Longitude at Sea.

2. That such Information has not been given as will enable other Workmen to make other Time-keepers of equal goodness with that which is certified to have kept the Longitude.

Or 3. That they will come to so enormous a Price as to be out of the Reach of Purchase.

From the Benefit of the first Objection (even if it was founded in Truth, which I utterly deny) the Commissioners have surely precluded both themselves and the Nation, as with Respect to me, by their repeated Orders and Instructions, and after leading me on for near Half a Century, to employ my whole Time and make long Voyages for *perfecting* the Invention, they can never be permitted now to come and say *the Invention itself* is good for nothing. Should any one however continue to propagate such an Opinion, I beg leave, in Contradiction to it, to offer that of Sir *Isaac Newton*, and that

of *Martin Folkes, Dr. Halley, Dr. Smith, Mr. Graham*, and eight other Persons of great Eminence, both publicly given to the House of Commons and to be found in the Journals, viz. *Sir Isaac's* in Vol. 17, Page 677, and the others in Vol. 29, Page 547.

The second Objection is flatly contradicted by Evidence lately before the House of Commons, by which it appears that the Description and original Drawings from which the Watch was made, as given in by me upon Oath, are printed and published; and that *Mr. Mudge* (the only one of the Watchmakers to whom the Discovery was made, who has been examined by the House of Commons) declar'd he could make these Watches as well as I can. Moreover I am ready, on Condition of receiving the Remainder of what's due to me, upon Oath to give all manner of future Information and Instruction in my Power; and I hope it could never enter into any Man's Idea of general Practicability, that I should actually teach every indifferent Workman in the Nation, and furnish each of them with a Set of Tools for the Trial of his Ability, at my own Expence, before I could be entitled to the Reward.

With Regard to the third Objection, no Estimate of the future Expence can (from the Nature of the Subject) be grounded upon any Authority better than that of Opinion. The Price of common Watches, where each Part is made by a different Workman, bears no Proportion to what must necessarily be charged

charged by any Man who was to make the whole with his own Hands: the same Reduction will naturally take place when a Number of Workmen are instructed to make the different Parts of these. My Opinion is, that they might in a very few Years be afforded for about £.100 a-piece, and if a Reduction of the Machinery can be effected (which I am strongly inclined to think is the Case, but have not had an Opportunity of proving by Experiment for want of my Models) the Expence may be reduced to about 70 or 80 l.

By this Time I think the Reader may naturally exclaim, How can all these Things be? What can induce a Number of Noblemen, Statesmen and Officers of the first Rank and most unblemished Characters; what can induce the President of the Royal Society, and the Professors of the Universities (to each of whom his Majesty has been most graciously pleased to order Payment of 15 l. per Day for every Board of Longitude they attend) and what can induce the Astronomer Royal, thus to discourage an Invention which they are specially constituted to improve, protect, and support? I might answer with Mr. Maskelyne, "that's none of my Business to account for."—*The Facts are so*, and this public Relation of them is extorted from me, by a Conviction that no other Way is left me to obtain Justice, or so likely to prevent the Invention from perishing. However, if it is expected of me, like Mr. Maskelyne, to deliver an Opinion on this Point, I shall declare what I believe *very sincerely*,
that

that by far the greater Part of the Commissioners are perfectly innocent of the Treatment I have met with: most of them are Commissioners by Virtue of great Employments which engage their Time and Attention: A Board so constituted is continually changing; and this being a Matter of Science which to many may seem rather abstruse, it was very naturally left to the Management of a few of those Members who stand in the most immediate Relation to Science, and whose Opinions, upon a Business of this Nature, the rest of the Board had too much Modesty to call in Question. How well they have merited that Degree of Confidence is left to the impartial World to determine.

To return again to Mr. *Maskelyne's* Account: He, as I think has been already shewn, having said and done every Thing in his Power to the Dishonour and Discouragement of my Invention, scruples not to sum up his Opinion of it in the following Terms:

“ That Mr. *Harrison's* Watch cannot be
 “ depended upon to keep the Longitude
 “ within a Degree, in a *West-India* Voyage
 “ of six Weeks, nor to keep the Longitude
 “ within Half a Degree for more than a
 “ Fortnight, and then it must be kept in a
 “ Place where the Thermometer is always
 “ some Degrees above freezing: that, in
 “ case the Cold amounts to freezing, the
 “ Watch cannot be depended upon to keep
 “ the

“ the Longitude within Half a Degree for
 “ more than a few Days, and perhaps not
 “ so long, if the Cold be very intense :
 “ nevertheless, that it is a useful and valua-
 “ ble Invention, and in Conjunction with the
 “ Observations of the Distance of the Moon
 “ from the Sun and fixed Stars, may be
 “ of considerable Advantage to Navigation.”

Having sufficiently refuted the first Part
 of this Opinion already, it only remains for
 me to make such Remarks on the Lunar
 Method of finding the Longitude, as this
 coupling of my Invention with it seems to
 call upon me for,

It is with Reluctance that I follow Mr.
Maskelyne into a Subject in which I may
 seem, like him, to be actuated by a selfish
 Preference to my own Scheme ; however, as
 I shall give my Reasons for what I advance,
 I will not hesitate to submit them to the Pub-
 lic. I beg to be understood as a warm and
 declared Friend to that and every other
 Mode which can be devised of ascertaining
 the Longitude at Sea, so long as they keep
 within the Bounds of Reason and Probability.
 Here are now two Methods before the Pub-
 lic ; Wou'd to God there were two Hundred !
 The Importance of the Object would war-
 rant public Encouragement to them all ;
 but, called upon to say something on the
 Subject, I think it incumbent upon me to
 point out those Limits beyond which its
 Utility cannot, from the Nature of the
 Thing, be extended.

The

The Method of finding the Longitude by the Moon, in which Mr. *Maskelyne* is in a pecuniary way interested, is this,—If the apparent Distance between the Sun and Moon, or between the Moon and some fix'd Star, at any certain Part of the Globe, was for every Hour of the Year known; and if a Navigator, when at Sea, could also, by Observations, ascertain what is the apparent Distance, at the Place where he is, between the Sun and Moon, or between the Moon and a Star, and likewise their respective Altitudes; and if he could also, at the same Moment, ascertain the Time of the Day, either by an immediate Observation of the Sun, or by a Watch which would keep Time pretty exactly from the last solar Observation; these Matters of Fact being given, the Difference of Longitude may from thence be calculated. I admit the Principle to be absolutely true in Theory. The Lunar Tables, for which the Rewards have been given, are calculated to shew the Distance between the Sun and Moon, or Moon and Stars, at *Greenwich*; I admit the Practicability of making such Tables; but with Regard to the other Requisites, I beg Leave to observe that, for six Days in every Month, the Moon is too near the Sun for observing, consequently, during those Days, the Method falls *totally* to the Ground; that for about other thirteen Days in every Month, the Sun and Moon are at too great a Distance for observing them at the same Time, or are not at the same Time visible; therefore, during those 13 Days, we must depend

pend upon Observations of the Moon and Stars, and upon a Watch to keep Time, from the last Solar Observation with sufficient Exactness, which common Watches cannot be depended upon to do; well therefore might Mr. *Maskelyne* admit that my Invention would become of considerable Value, even if taken in Aid of the Lunar Tables. I leave the Reader to judge of the Practicability of making these Observations from what follows:

To ascertain the Longitude by the Moon and a Star, requires a distinct Horizon to be seen in the Night, which is next to impossible, and if you have not an Horizon, the Altitude of neither Moon nor Star can be taken: It also requires (and this perhaps when a Ship is in a high Sea) the Distance of the Moon and Star, in order to come at which, the Image of one of them must be reflected through a silvered Glass, and the other seen through an unsilvered Part of the same Glass; and they must be brought into Conjunction in the Line that connects the silvered and unsilvered Parts, and this to an Exactness only true in Theory, for an Error of a Minute of a Degree committed in this Observation, will mislead the Mariner Half a Degree in his Longitude: Now I call upon any Astronomers of Reputation publickly to declare, that they have, even at Land, and with the best Instruments *Europe* affords, been able to make this Observation of the Moon and a Star with *any thing like* the Precision required to determin the Longitude within

within the Limits required by the Act of the 12th of Queen *Anne* ; I know it cannot be done. Nay I further call upon any such Astronomers to declare, whether even in Observations of the Distance between the Sun and Moon, two of them observing together have *generally speaking* agreed in this Observation within a Minute of a Degree : I know that in general the Difference between the best Observers even at Land will be more, and as a farther Proof of this Assertion, I refer the Reader to the Note below :† And if

† In the fifth Volume of M. DE LA CAILLE's Ephemerides, Page 31, he says, " that any Person would be in the wrong to suppose that the Longitude at Sea can be determined by the Moon, to a less Error than two Degrees, let the Method which is employed be never so perfect, let the Instruments, of the Sort now in use, be never so excellent, and let the Observer be the most able and accomplished. For if we examine, without prejudice, all the Circumstances which enter into the Calculation and into the Observation of a Longitude at Sea, we shall be easily convinced, that it would be ridiculous to maintain, that the Sum of the inevitable Errors should not amount to five Minutes of a Degree, that is, to two Degrees and a half of Longitude. N. B. M. DE LA CAILLE published this in the Year 1755, and is universally allowed to have been an excellent Observer, and made several Voyages by Sea, where he made Trials of this Method by the Moon.

Dr. HALLEY and Dr. BEVIS (as appeared to the Honourable House of Commons upon an Examination of the latter) did, with an excellent HADLEY's Quadrant, rectified by Mr. HADLEY himself, and in his presence, attempt to take the angular Distance of the Moon from ALDEBARAN, a
Star

if these Matters of Fact are still doubted, I shall beg Leave to call upon Mr. *Maskelyne* and Mr. *Green* to declare how near they, with Admiral *Tyrrel* agreed in determining the Longitude by the Sun and Moon in their Voyage to *Barbadoes*; and also whether during that Voyage they ever did determine their Longitude by the Moon and Stars.— I know they did not, for they found the Observation too difficult, and indeed *it is only true in Theory*.

From the foregoing Premises I infer,

1st. That during six Days in every Month, no Observations can be made by this Method to ascertain the Longitude at Sea.

2^{dly}, That during 13 other Days in each Month, it is impracticable to ascertain it by this Method with any Instruments hitherto contrived, or which the Nature of the Service to be performed seems to admit of

And 3^{dly}, That during the remaining 11 Days in each Month, when the Sun and Moon may, if the Weather is clear be observed at the same Time, no Reliance can safely be placed upon the best Instruments in the Hand of the best Observer for ascertaining the Longitude within the Limits of the Star of the first Magnitude; but with such bad Success (some of the Observations removing GREENWICH from itself almost as far as PARIS) that Dr. HALLEY seemed to be out of Hope of obtaining the Longitude by this Method.

the Act of Queen *Anne*; and consequently, that how valuable soever the Lunar Tables may be for correcting a long dead Reckoning, and thereby telling us *whereabouts* we are, when we are not afraid of falling in with the Land, yet even during these 11 Days, they do not extend to the Security of Ships near the Shore.

This *Method* of ascertaining the Longitude by the Moon has already cost the Publick the Sum of 6,600*l.* at least, and yet no proper Experiment has been made of it.

I shall not presume to make any Reflections on the different Treatment the two Inventions have met with, nor will I take up more of the Reader's Time by a Detail of the very earnest Attention paid by the *French* Government to this Object. If our Rivals in Commerce and Arts *should* rob us of the Honour as well as the first Advantages of the Discovery, I hope it will be admitted that the Fault is not mine: And I likewise flatter myself that I have now furnished sufficient Materials for the Justification of my Friends, and for shewing that the Cause which they from publick spirited Motives had the Goodness to espouse, was not unworthy of their Patronage.

Red-Lion-Square,
June 23, 1767

JOHN HARRISON.

F I N I S.

